Constructivism and Instructional Design

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Introduction

After careful review of the papers in this issue of *Educational Technology* we have concluded that extreme constructivism[1] does indeed represent an alternative view to Instructional Systems Technology, but that some of the assumptions and prescriptions of a more moderate constructivism are consistent with our views of instructional design. Constructivism advocates are fond of characterizing the instructional view in order to make their points stand out in bold relief against what they believe are inappropriate assumptions and practices. It is unfortunate that in making these characterizations they have not cited the work of instructional design theorists, but rather supporters of the constructivist movement. Too often such characterizations become straw men which are also not supported by members of the IST[2] community. For example, Bednar, Cunningham, Duffy, and Perry (1991) and Cunningham (in this issue) cite the extreme views of Lakoff (1987), which Cunningham labels "Objectivism," as the theoretical foundation of IST. We do not accept these extreme views as foundational to our own work, and would surmise that other instructional design theorists would be equally hesitant to acknowledge this view as representative of their work.

At Utah State University we are attempting to extend instructional design theory or IST. Our work may not reflect the views of the IST community at large. Nevertheless, we have been careful to identify our own assumptions and their implications for second generation instructional design theory (ID_2).[3] In this paper I will review these assumptions and contrast them with corresponding assumptions of constructivism as reflected by the authors in this issue. In this effort I shall identify those constructivism assumptions that are consistent with our assumptions and those which are clearly in opposition to our view.

In addition I will identify the instructional design implications of our ID_2 assumptions and will contrast these with the instructional design implications of constructivism as represented by the authors of this issue.

Finally, I will take a very pragmatic stance and argue that the assumptions of both ID_2 and constructivism may be equally valid or invalid. I will suggest a set of pragmatic criteria which has led us to accept the assumptions of ID_2 and to reject the opposing assumptions of extreme constructivism. Ultimately the instructional design prescriptions of either position must be established by empirical verification. I will also suggest some of the difficulties in obtaining such verification, including the possibility that the instructional products resulting from either position may have far more in common than they have in opposition, making an adequate empirical test extremely difficult.

Assumptions of ID_2

ID_2 is based on the following assumptions. The first three are quoted from Merrill, Li, and Jones (1990b).

Mental Models

"Our concept of ID_2 is cognitive rather than behavioral. We start from the basic assumption that learning results in the organizing of memory into structures, which we may term *mental models*. To this we adopt two propositions about the learning process from cognitive psychology:

- **organization** during learning aids in later retrieval of information, and
- **elaborations** generated at the time of learning new information can facilitate retrieval.

Organization refers to the structuring of knowledge; while elaboration refers to the explicit specification of relations among knowledge units."

Categories of Knowledge

"From ID_1 [first generation instructional design[4]] we retain Gagne's fundamental assumption:

- there are different learning outcomes and different conditions are required to promote each of these different outcomes (Gagne 1965, 1985).

We propose to extend these fundamental ideas as follows:

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- a given learned performance results from a given organized and elaborated cognitive structure, which we will call mental models; Different learning outcomes require different types of mental models;
- the construction[5] of a mental model by a learner is facilitated by instruction that explicitly organizes and elaborates the knowledge being taught, during the instruction;
- there are different organizations and elaborations of knowledge required to promote different learning outcomes."

Knowledge Representation

We assume that knowledge can be represented in a knowledge base external to the learner.

> "We make no claims about how cognitive structure is organized and elaborated, as this is not well understood. We stand on the weaker, and more defensible, assumption that we can analyze the organization and elaborations of knowledge outside the mind, and presume that there is some correspondence between these and the representations in the mind."

Enterprises

A complex mental model enables the learner to engage in some complex human enterprise or integrated activity. We assume that ID_2 should teach the organized and elaborated knowledge needed to facilitate the development of mental models, thus enabling students to engage in complex enterprises.

Knowledge Strategy Separation

We assume that instructional strategy is somewhat independent of the knowledge to be taught. We assume that the same strategy can be used to teach different topics and even different subject matters.

Strategy Categories

In the previous paragraphs we assumed that different organizations and elaborations of knowledge are required to promote different learning outcomes; we further assume that there are different kinds of instructional strategies necessary to promote these different kinds of learning outcomes. Different instructional strategies are required to promote the acquisition of different kinds of knowledge and skill. We assume that these strategy categories are not domain specific. Using the appropriate instructional strategy will improve the student's acquisition of the knowledge or skill.

Strategy Universality

We assume that these instructional strategies are somewhat universal, that is, to learn a particular type of knowledge or skill, a particular learner must engage in a set of instructional transactions similar to those required by any other learner.

Assumptions of Constructivism

The authors in this issue seem to subscribe to the following (the quotations are from Bednar *et al.*, 1991):

Learning Constructed

Knowledge is constructed from experience. "... learning is a constructive process in which the learner is building an internal representation of knowledge..."

Interpretation Personal

There is no shared reality, learning is a personal interpretation of the world. "... learning results in ... a personal interpretation of experience."

Learning Active

Learning is active. "Learning is an active process in which meaning is developed on the basis of experience."

Learning Collaborative

Meaning is negotiated from multiple perspectives. "Conceptual growth comes from the sharing of multiple perspectives and the simultaneous changing of our internal representations in response to those perspectives..." Sagredo (Cunningham) agrees: "The role of education...is...to promote collaboration with others to show the multiple perspectives that can be brought to bear on a particular problem and to arrive at self chosen positions to which they can commit themselves..."

Learning Situated

Learning should occur in realistic settings (situated or anchored). "...learning must be situated in a rich context, reflective of real world contexts..."

Testing Integrated

Testing should be integrated with the task not a separate activity. "...the measure of learning...is how instrumental the learner's knowledge structure is in facilitating thinking in the content field..."

Comparison of Constructivism and ID_2

On the surface these premises seem to be consistent with our ID_2 perspective. However, the implications of these assumptions, as stressed by some of the authors in this issue, make most of them inconsistent with the assumptions of ID_2.

Mental Models versus Constructed Learning

"Knowledge [a mental model] is constructed from experience." We agree. We do not subscribe to the *tabula rasa* straw man of extreme objectivism. I don't know anyone who seriously assumes that knowledge is merely "transferred" to the memory of the student. Mental models are constructed by the learner as a result of experience. The student needs a variety of experiences to construct an adequate mental model. A mental model is modified as a result of every new experience. On this point ID_2 has no disagreement with constructivism.

Categories of Knowledge and Personal Interpretation

"There is no shared reality, learning is a personal interpretation of the world." This is a point of major disagreement. While ID_2 subscribes to learning as constructed, we do not assume that the resulting cognitive structure is completely idiosyncratic, unique to each individual. We assume that the semantics or content of cognitive structure is unique for each individual, but that the syntax or structure is not. By analogy, there is an infinite number of declarative sentences in the English language, but, while these semantics can differ significantly, they all have the same syntax. In a like way, the content of each individual's mental models may be different, but ID_2 assumes that the structure is the same. Whatever the mechanisms of mind—electrical, chemical—and the functioning of mind—encoding, memory, retrieval—ID_2 assumes that in this respect all men are created equal. Further, we assume that such functions can be known and used to guide instruction.

Knowledge Representation and Constructed Learning

Some of the authors in this issue have taken a strong stand for constructivism with regard to knowledge analysis and representation (Bednar, Cunningham, Duffy, and Perry, 1991). Their corollaries of the above assumptions include the following:

Content cannot be prespecified. There are no different types of learning, especially separate from content. There can be "...no meaningful construction (no authentic activity) if relevant information is prespecified." Furthermore, they have suggested that there can be no categories of objectives independent of subject matter or domain, that all objectives are unique to different subject matters. The only allowable content is "authentic tasks" which, if "decontextualized," that is, taken from the milieu in which they occur, are no longer "authentic" and hence have lost their value for enabling the student to construct knowledge, except for the "artificial context of the classroom."

ID_2 stands in direct opposition to these extreme constructivist views. We have proposed a syntax for knowledge representation (Jones, Li, and Merrill, 1990) which assumes that knowledge, across subject matter areas, can be represented in knowledge frames of three types—entities, activities, and processes. We have further assumed that these frames can be elaborated in four ways via properties, components, abstractions, and associations. This knowledge structure enables us to represent knowledge in a knowledge base. This representation is independent of any particular individual. The same knowledge structure can be used for a wide variety of knowledge domains. Furthermore, we assume that in order for adequate instruction to occur, that knowledge must be prespecified. Technology based delivery systems such as CBI or interactive video require that knowledge be prespecified and represented in some form of knowledge base. ID_2 proposes that this representation has a syntax that will allow the representation of diverse domains using the same knowledge structure.

Some of the advocates of constructivism have equated prespecified with linear, nonflexible, or nonexecutable. These are unwarranted extrapolations. An intelligent tutoring system that can carry on a dialogue with a student must have prespecified knowledge. In fact, specifying enough knowledge to make such systems viable is one of the challenges ITS has encountered. Prespecification does not mean that the knowledge is static, linear, or that all student responses have been anticipated. An appropriate syntax for representation makes such intelligent systems possible. Hence, it should not be assumed that because ID_2 advocates a particular syntax that this syntax enables only static, linear, or noninteractive presentation of the knowledge.

Two of the authors in this issue (Spiro *et al.*, and Bransford *et al.*) have described technology delivered instruction in the constructivist tradition. Spiro *et al.* describe technology based hypermedia delivery based on Cognitive Flexibility Theory. This requires that the knowledge be represented in some knowledge base. The Cognitive Technology Group describe video scenarios of complex problem solving situated in real-world-like settings. This requires some form of knowledge base implemented by the technology. If knowledge is represented, then there must be some form of representation. In our opinion, the knowledge representation system of ID_2 could be used to represent the information described by both of these research groups. It is not clear from the information available whether Spiro, Bransford, and their colleagues subscribe to the view that each of these representations must

be unique, or whether they would accept a common syntax for knowledge representation. However, they must disagree with Bednar, Cunningham, Duffy, and Perry concerning the prespecification of knowledge. In both of their cases the knowledge has been prespecified.

Enterprises

We have indicated that some of the limitations of first generation instructional design, including our own work, are that, "ID_1 content analysis does not use integrated wholes which are essential for understanding complex and dynamic phenomena," and "ID_1 teaches pieces but not integrated wholes." Some of the authors in this issue (Bednar *et al.*, 1991) have also expressed this limitation as follows: Objectivism holds that: "Knowledge can be completely characterized using the techniques of semantic analysis (or its second cousin, task analysis). ...thought is atomistic in that it can be completely broken down into simple building blocks, which form the basis for instruction. Thus, this transfer of knowledge is most efficient if the excess baggage of irrelevant content and context can be eliminated." In order to contrast constructivist views these authors have stated the most extreme view.

Constructivism assumes that, "Learning should occur in realistic settings (situated or anchored)." These authors (Bednar *et al.*, 1991) go to the opposite extreme, however, and suggest that an "authentic task" must contain no isolated tasks, must be a real-world task, must be in context, and must involve no simplification of that context. Furthermore, they argue that context cannot be separated from use. While advocating the teaching of more integrated enterprises (see Gagne and Merrill, 1990), ID_2 still holds that these enterprises are constructed of components of known syntax and that analyzing a task into these components enables the use of transaction shells to efficiently and effectively enable student interaction as described latter in this paper. ID_2 feels that teaching authentic tasks in context is a desirable part of the instruction. But to deny simplification, to deny isolating a generality from context, to insist on all instruction occurring only in the context of use, is to deny some of the great advantages of learning from instruction vs. learning only from experience.

To insist on context never being separated from use is to deny the teaching of abstractions. An abstraction is one of the powerful capabilities of the human mind, the ability to decontextualize ideas from context and apply them in a new context. We agree that the initial instruction must be contextualized, that the learner must experience the abstraction in a variety of contexts and applications; but we emphatically insist that at some point in the instruction these abstractions not only can, but must, be decontextualized if the student is to gain the maximum benefit and ability to transfer generalities and tools to new situations.

Knowledge Strategy Separation

While the basic assumptions identified for constructivism don't seem to demand such a narrow view, some of the authors (Bednar *et al.*, 1991) insist that there can be no content-independent instructional strategies. As indicated, a fundamental assumption of ID_2 is that strategy and subject matter content are somewhat independent.

Strategy Categories

While the basic assumptions identified for constructivism don't seem to demand such a narrow view, some of the authors (Bednar *et al.*, 1991) insist that there are no categories of objectives, and hence there can be no categories of strategies. They further insist that all objectives are unique to the context in which they are imbedded. As indicated, a fundamental assumption of ID_2 is that there are classes of instructional transactions which are appropriate for promoting acquisition of particular types of mental models; that these fundamental instructional transactions can be adapted to a wide variety of situations and used with different subject matter contents.

Strategy Universality

While the basic assumptions identified for constructivism don't seem to demand such a narrow view, some of the authors (Bednar *et al.*, 1991) insist that there is no "average learner," that each learner is unique. Furthermore, they insist on no external control of instructional events, implying that all instruction must be under learner control. This extreme view would insist that all learners must have instruction that is unique to them—that all learners must control their own instruction. This makes instructional design prescriptions via any universal set of instructional strategies impossible. As indicated, a fundamental assumption of ID_2 is that there are classes of instructional strategies which are appropriate for all learners to enable them to construct appropriate mental models of particular kinds of learning tasks.

Learning Active

Yes! Yes! ID_2 insists on an active learner and that this activity be meaningful, not just response for response sake (see Merrill, 1988). The name *Instructional Transaction* was deliberately chosen to represent an active learner. An instructional transaction is defined as "...a mutual, dynamic, real-time, given-and-take between an instructional

system and a student in which there is an exchange of information" (Merrill, Li, and Jones, 1990b; Li and Merrill, 1991; Merrill, Li, and Jones, in press).

Learning Collaboration and Meaning Negotiated from Multiple Perspectives

This assumption is not inconsistent with ID_2 except that we would insist that not all learning need be collaborative. There are occasions when individual learning is more effective and more efficient.

We agree that a divergent set of examples and contexts is necessary for promoting adequate transfer to new situations. However, some of the authors (Bednar *et al.*, 1991) have argued that the use of examples to "...highlight critical attributes and systematically manipulate the complex of irrelevant attributes..." is not appropriate, since life seldom consists of nicely organized examples; hence, they advocate "...slices of life..." as more authentic. They are right, of course, life is not regular; that is why learning from instruction is more efficient than learning only from experience. We agree that multiple perspectives are necessary, but we also advocate that these multiple perspectives should be carefully chosen (preselected) to enable the learner to abstract from these situations that which is relevant and that which is not. It is a straw man to insist, as these authors do, that the selection of cases which highlight attributes necessarily means that these cases are "...clear-cut examples with only one correct solution..." or that "...there is little that is authentic about these examples."

Salviati (Cunningham) argues that "...the role of education...is to promote collaboration with others to show the multiple perspectives that can be brought to bear on a particular problem and to arrive at self chosen positions to which they can commit themselves, while realizing the basis of other views with which they may disagree." "...learning is infinite and not subject to the sorts of analyses favored by objectivists except in the most trivial cases."

These constructivists argue that specific learning objectives are not possible—that meaning is always constructed by, and unique to, the individual—that all understanding is negotiated. In our opinion, this is a very extreme position. Let me speak up for the vast amount of "trivial cases," those situations where shared meaning is not only possible but necessary.

Do we want students to have a "self chosen position" with regard to the sound of letters in learning to read? Do we want students to have a "self chosen position" about the meaning of the integers? Will a machine allow us to have a "self chosen position" about how it works? Can students have a "self chosen position" about which keys on a keyboard correspond to certain letters on the screen? Do we want students to have a "self chosen position" about how to do the arithmetic operations of add and subtract? How to solve a linear equation? Do we want drivers to have a "self chosen position" about the meaning of a red light? of a stop sign? Will a natural law allow us to have a "self chosen position" about its relationships? Can a student have a "self chosen position" about Ohm's law?

If I hire a surgeon to do heart surgery, PLEASE let me have one who has learned the trivial case and knows that my heart looks like every other human heart. Please don't let him negotiate new meanings and hook up my veins in some "...self chosen position to which [he] can commit [himself]." I want him committed to the standard objective view. The trivial case is not so trivial. To dismiss so casually the objective case is perhaps the greatest danger of radical constructivism.

Testing Integrated

On the surface there is nothing inconsistent about this assumption and ID_2. We have also advocated that testing be more integrated and that it should be consistent with the learning objectives of the task. However, we would not insist that all testing must be integrated. It is possible to have a separate assessment of learning achievement.

These constructivists, however, insist on integrated testing for another reason, and with this argument we do have disagreement. They insist that learning cannot be decontextualized; hence, testing cannot be decontextualized. Thus, the only possible measure is to observe the learner's performance in the context of the authentic task. We would insist that generalities (abstraction models) can be abstracted (decontextualized) and then applied in another context. We would argue that the most adequate assessment is not performance in the learning task, but performance in another, previously unencountered, task where the abstracted (decontextualized) learning can be applied. To deny this transfer of knowledge is to deny one of the mind's most remarkable capabilities and to limit the transfer of learning which, ironically, is one of the concerns of constructivism in the first place.

ID_2 and Instructional Design

Using the previously identified assumptions, ID_2 is a technology-enabled approach to instructional design that has as primary goals: to enable subject matter experts with minimal training or experience in instructional technology to develop effective technology-delivered instructional materials; to ensure that these instructional materials provide learning experiences that use the advanced capabilities

of the computer to provide meaningful experiential learning activities; and to decrease the cost of instructional development by an order of magnitude with no loss in instructional effectiveness.

We are designing an instructional design and delivery system (see Merrill, Li, and Jones, 1990a, 1990b, 1990c, 1991 in press) composed of two primary subsystems: a knowledge base and a family of instructional transaction shells. The knowledge base is a representation of all of the knowledge and skill to be taught. Transaction shells enable the learners to interact with this knowledge in ways that best enable them to build appropriate mental models.

Instructional transactions[6] are instructional algorithms, patterns of learner interactions (far more complex than a single display and a single response) which have been designed to enable the learner to acquire a certain kind of knowledge or skill. Different kinds of knowledge and skill require different kinds of transactions. The necessary set of these instructional transactions are designed and programmed once, like other applications such as spreadsheets and word processors. These instructional programs are called *instructional transaction shells.* These transaction shells can then be used with different content topics as long as these topics are of a similar kind of knowledge or skill.

Authoring by way of *instructional transaction shells* consists of selecting those patterns of interactions which are appropriate for a given topic and merely supplying the subject matter content to the knowledge base in a form that can be used by the transaction shell. There is no need to determine every display; to determine a branching structure; to select what kinds of questions to use; to specify answer processing. Once the transaction shells have been developed they can be used over and over again with no need for extensive instructional design or programming.

Constructivism and Instructional Design

Sagredo (Cunningham) suggests that instructional design for a constructivist consists of the following: "...selecting tasks which are relevant to the child's lived experience...The teacher or instructional developer then provides access to tools which can be used to better understand or construct solutions to the problem...often approached with a collaborative group. No separate test is required. The 'proof' ...is the successful completion of the task."

While IST has a well-documented methodology, it is not clear how a constructivist would go about carrying out these steps. How does one select relevant problems? By job analysis? By deciding what students should know? By looking at learner capabilities? By task analysis? But these are the techniques of IST. If we set an objective, if we assess learner capabilities, if we do a task analysis, are we going to choose irrelevant tasks? On the surface, I see little difference between the task analysis of IST and selecting a relevant task for constructivism; except that a constructivist may be less systematic about the procedures for choosing relevant tasks.

Is selecting the process of discovery orientation (provide tools and encourage students to construct solutions to problems) selecting an instructional strategy? Is guiding a student in the discovery (problem solving)process using these tools an instructional strategy? Is using a collaborative (cooperative) problem solving approach a strategy? Are there occasions when individual effort is more appropriate? Constructivism advocates a discovery process collaborative instructional strategy—whereas instructional design does not exclude this strategy, but may also choose alternative strategies when they are appropriate. On the surface the constructivism instructional strategy seems to merely have a narrower point of view and be limited to certain types of instructional outcomes.

Can data be gathered during the execution of an activity? Combined with other data from observation, can this constitute a test? Instructional design would say yes. Constructivism seems to be merely a limiting position excluding more objective measures, whereas instructional design would advocate using that assessment technique most appropriate to the situation.

On the surface the instructional design procedures recommended for constructivism do not seem contrary to IST or ID_2. ID_2 certainly would not select an irrelevant task (although the straw man arguments of Sagredo seem to imply that this is the case for typical instructional design). A transaction is, among other things, providing access to the student of the tools necessary to understand and solve the problem. ID_2 certainly supports successful completion of the task but would not object to an external assessment of achievement. It is the extreme interpretation of these authors, including Cunningham (Bednar *et al.*, 1991), which is troublesome.

They argue that to be relevant a task must be imbedded in a real-world context. It cannot be simplified. It cannot be equated to any other task and must therefore be unique. It cannot be prespecified. It cannot be classified as to type of knowledge or skill required. The learning must be completely unique. No two learners will necessarily come to understand the task in the same way. The teacher must model the process rather than provide any conclusion, but the teacher must not be scripted. The generalities cannot be decontextualized or

they will lose meaning. Are these restrictions necessary limitations of constructivism?

The examples of experiential instruction described by Spiro *et al.* and Bransford *et al.* do not adhere to this strict interpretation of constructivism. They meet the fundamental assumptions of active learning and situated problems, but necessarily they involve prespecification and identification of intended outcomes. In fact, the technology-based instruction described by these authors is very consistent with that which would be developed using ID_2. It is our hope that the experiential environments resulting from the application of Instructional Transaction Theory would result in learning interactions very similar to those described by Spiro, Bransford, and their associates.

Constructivism and Instructional Transaction Theory

As indicated above, Instructional Transaction Theory (ID_2) is consistent with a moderate interpretation of some of the assumptions of constructivism. However, ID_2 is inconsistent with the extreme views put forth by some of the authors in this issue of ED TECH.

Who is right? In the eternal scheme of things, none of us understands very much about how humans learn; how the mind functions. What is mind? What is knowledge? Both sets of assumptions may be wrong together. They are undoubtedly both incomplete. So, how does one choose?

We take the pragmatic stand that there may be competing systems of instruction based on different assumptions about learners and learning. It is difficult to establish the truth of our assumptions, but the propositions that follow from these assumptions can be submitted for empirical verification. Support for a given proposition still does not establish the truth of the assumption on which it is based, since the same proposition may be derived from a different set of assumptions. Such is the case with the more moderate views of constructivism. The instructional prescriptions that follow from ID_2 are very similar to those that follow from a moderate constructivism: relevant tasks, active learning, and experiential learning. As compelling as the arguments of the constructivists may be, there is no empirical evidence in support of their assumptions, and little empirical evidence in support of the instructional design propositions derived from these assumptions. On the other hand, there is little empirical support for ID_2 either.

However, an extreme constructivist position, while it may be appropriate for some types of learning in a general education environment, is contrary to the solution of some of our most pressing educational problems.

As argued above, must of what needs to be learned must be shared. There are in fact agreed-upon concepts, principles, facts, processes, procedures, and activities that learners must learn. The extreme constructivist position that learners can "...arrive at self chosen positions..." is nonsense. A significant amount of what every child must learn and certainly what any adult must learn to earn a living and function in society is objective, must be shared, can be very similar, must be very similar from one individual to the next. The world is composed of Cunningham's "trivial cases."

Second, instructional development is too cost intensive. We cannot afford well-designed effective instruction because of the tremendous cost of developing it. Hence, most of our instruction is stand-up presentation that everyone acknowledges as inadequate, irrelevant, incomplete. Those existing cases of dynamic, effective, appealing, experiential environments (such as the environment described by Bransford *et al.* in this issue), which everyone recognizes as significant improvements over our usual instructional experiences, are extremely expensive to develop and are thus out of reach for most learners.

The real challenge is how to make such effective learning environments available to all learners most of the time. To assume that these environments do not exist because instructional designers have a theoretical bias which prescribes less effective instruction (as suggested by Bednar *et al.*, 1991) is an insult to those who have dedicated their life to trying to build better instruction. It is not the theoretical bias, but rather the existence of practical tools available for building such systems that is the real limitation. Constructivism provides a rationale for such learning systems. We subscribe with enthusiasm to the work of Spiro and his associates in delineating Cognitive Flexibility Theory. It provides a theoretical rationale for what we are trying to do. But we resent the implications of Bednar *et al.*, which suggest that IST has deliberately developed instruction which is ineffective because instructional designers believe that this inadequate instruction is better.

ID_2 is an attempt to build a technology that enables a significantly more cost-effective approach to instructional development. The output of this technology would be effective situated (in the moderate sense) experiential learning environments enhanced by more directed instructional strategies. This technology is made possible by the assumptions of ID_2; that knowledge has a syntax that is universal across domains; that knowledge can be represented using this syntax in a knowledge base external to the learner; that learners can interact with this knowledge in a variety of ways; but that

certain types of interactions are necessary if a learner is to acquire a particular type of knowledge or skill; that prespecified computer programs (transaction shells) can enable these interactions and thus enable a learner to construct appropriate mental models of this knowledge.

Extreme constructivism, represented by some of the authors in this issue, makes such a technology difficult, if not impossible. Rather than contributing to a more efficient and effective instructional technology, extreme constructivism may in fact inhibit technological solutions to our pressing instructional needs. A technology built on the assumptions of extreme constructivism—that content cannot be prespecified because every learning task is unique; that learners learn in idiosyncratic ways; that objectives or learning outcomes are content specific; that there are no categories of objectives; that there is no domain independent instructional strategy; that there can be no external control of the instructional events except that which the learner chooses; that there are no isolated tasks, only real-world tasks; that there can be no simplification of content; that content cannot be separated from use; that the teacher must model the process but must not be scripted; and that there must always be alternative views—is extremely hard to conceive. In an attempt to solve what they perceive as inadequacies in our current instructional approaches, extreme constructivists propose a methodology that is even more labor intensive, thus insuring that even less effective instruction will be available in the future than is now the case.

Conclusion

IST as represented by our own work, ID_2, applauds the creative work of Spiro *et al.* and Bransford *et al.* Much of our own work is an attempt to provide tools that enable the development of the type of experiential environments that they describe. We would advocate that moderate constructivism has much that should be considered by instructional designers. On the other hand, extreme constructivism, as represented by the other authors in this issue, goes beyond the pale. The assumptions that they make about the learning process are unnecessarily restrictive and may actually prevent the more effective instruction that they seek. □

Notes

1. I have tried to reflect Constructivism as represented by the authors of the papers in this special issue including: Duffy and Jonassen; Cunningham; Spiro, Feltovich, Jacobson, and Coulson; Perkins; The Cognition and Technology Group; and supplemented by Bednar, Cunningham, Duffy, and Perry, 1991.

2. IST, Instructional Systems Technology, is the term used by Bednar *et al.* (1991) to refer to those of us who advocate a systems approach to instructional design and technology. I will adopt their acronym for use in this paper.

3. I will not try to represent the IST community at large in this paper, but will concentrate on our own view of instructional design and the assumptions underlying our approach. I will refer to our approach throughout this paper as ID_2 or second generation instructional design.

4. First generation instructional design includes the theories represented in Reigeluth (1983, 1987) and similar positions, such as Engelmann and Carnine (1982).

5. Our use of the word *construction* in this context is not an accident. We do not subscribe to the notion that mental models are merely "transferred" into the head of the student, but that students must be actively involved in constructing meaning, building an appropriate knowledge structure. However, we do believe that the structure necessary to engage in certain types of tasks must have similar syntax across different students. The syntax of the structure thus constructed is not therefore idiosyncratic to a particular student.

6. We first introduced the idea of an instructional transaction in Merrill 1983, 1987a. Subsequently Li and Merrill (1991) described instructional transactions in more detail.

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New Products

Book Describes Thinking-Skills Curriculum. *HOTS (Higher Order Thinking Skills: Using Computers to Develop Thinking Skills in Students at Risk)*, a book by Stanley Pogrow, has been published by Scholastic Inc., 730 Broadway, New York, New York 10003. The 235-page book, priced at $24.95, provides guidelines to computer coordinators and school administrators for implementing the curriculum developed by the author.

New Classroom Network Environment. "SchoolMate Plus," an expanded version of the Tandy SchoolMate network, has been announced by Radio Shack, 700 One Tandy Center, Fort Worth, Texas 76102. The new product helps teachers to keep track of student activity on the network, and allows teachers to send and collect electronic assignments.

Works of Art on Videodiscs. Three new videodiscs for schools, museums, and libraries have been announced by Belser Knowledge Services, 54 West 21st Street, New York, New York 10010. The videodiscs cover Nineteenth Century Paintings: A Selection, German Paintings of the Renaissance, and Dutch Baroque Paintings. The firm has also announced its new "Docent" software package, designed to be used along with these and other videodiscs to create lectures, presentations, and research documents. Belser is a German firm headquartered in Stuttgart.

Network Version of Math Software. A network version of its SuperSolvers "Outnumbered!" software package has been released by The Learning Company, 6493 Kaiser Drive, Fremont, California 94555. The network version runs on IBM computers using Novell Advanced Netware and the IBM Classroom LAN Administration System. The program is designed to help children in grades two to six develop essential math, problem-solving, and related thinking skills. Pricing details are available from the Learning Company.

Monograph on Technology in Adult Education. *Use of Technology in Adult Literacy: Minnesota's Programs*, edited by Terilyn C. Turner and Elizabeth Frick, has been published by the Minnesota Association for Continuing Adult Education, 494 Sibley Street, Fourth Floor, St. Paul, Minnesota 55101. The publication stresses the use of computer-aided learning activities. It is priced at $5.25.

Parent Communication System. Parent Link, a system to provide 24-hour access to daily information on homework assignments, scheduled tests, and learning activities, is available from 386 Systems Warehouse, 290 North University Avenue, Suite 212, Provo, Utah 84601. The system is intended to be used to increase parent involvement in schools. The voice-processing system is priced at under $2,000.

College Essay Software. "College Application Essay Writer," a word processing program designed to guide college-bound high school students in the writing of application essays, has been announced by Scholastic, Inc., 730 Broadway, New York, New York 10003. The program is available for both Apple II and MS-DOS computers and is priced at $29.95. The software is organized into three sections: Getting Ideas, Organizing Your Essay, and Composing Your Essay.

Learning Styles Inventory. A Macintosh HyperCard version of its "Learning Styles Inventory" program has been announced by Educational Activities, Inc., 1937 Grand Avenue, Baldwin, New York 11510. Priced at $98.00, the package includes two disks, two back-ups, and documentation. The software is designed for use with intermediate and secondary school students, and helps teachers to assess each student's preferred method or style of learning.

Student Edition of "dBASE IV." The Student Edition of dBASE IV Version 1.1 has been released by Addison-Wesley Benjamin Cummings Publishing Company, One Jacob Way, Reading, Massachusetts 01867. The Student Edition, licensed by Ashton-Tate, offers most of the features of the regular software package, but it is limited to 120 records. Details, including pricing, are available from Addison-Wesley.

Children's Desktop Publishing Program. "Children's Newspaper Maker," a program for the Apple IIGS with 1MB of memory and a compatible printer, has been released by Orange Cherry Software, Box 390, Westchester Avenue, Pound Ridge, New York 10567. Priced at $49.00, the software incorporates three levels of difficulty to accommodate a range of writing abilities for children who wish to produce their own classroom newspapers. The package includes two 3.5 disks.

Western Civilization Videodisc. "The Western Civilization Videodisc," containing more than two thousand still pictures from a wide variety of sources, is now available at $595.00 from Instructional Resources Corporation, 1819 Bay Ridge Avenue, Annapolis, Maryland 21403. Each image is annotated and indexed.